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"EFFECT OF INTEGRATION OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON GROWTH AND YIELD OF *KHARIF* RICE (*Oryza sativa.* L) "

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CONTENTS

Sl. No.	Chapter	Particulars	Page No.
1	Chapter-I.	Introduction	**4-5**
2	Chapter-II.	Review of Literature	**6-7**
3	Chapter-III.	Methodology	**8-14**
4	Chapter-IV	Results and Discussion	**15-23**
5	Chapter-V	Salient findings of the study	**23**
6	Chapter VI	References	**24-25**
7	Chapter VII	List of Publications	**26-27**

LIST OF TABLES

1.	Mean nutrient content of the organic manure resources used in the experiment (on dry weight basis)	**9**
2.	Growth parameters of rice at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)	**15**
3.	Yield and yield parameters of rice at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)	**17**
4.	Soil fertility status of rice at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)	**20**
5.	Economics of rice production as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)	**22**

LIST OF PLATES

1.	Lay out of the experiment	**18**
2.	General view of the experiment first year 2017	**18**

LIST OF FIGURES

1.	Grain yield and straw yield of rice as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)	**19**

Chapter I.

INTRODUCTION

Rice (*Oryza sativa* L) is one of the important cereal crop grown in India on an area of 43.19 million ha which is one quarter of the total cropped area with a production of 110.15 million tons (Anonymous, 2017). However, the productivity of rice is only 2.55 t/ha (milled rice) which is less compared to global productivity of 3.28 t/ha (Anonymous,2018). With growing population and increase in demand for rice, there is a need to re-orient the research efforts to ensure higher productivity with environmentally friendly technologies. The rice production has to be sustained in a continuous manner to meet the demands of growing Indian population which is expected to reach 1.63 billion by 2050 AD. Increasing the productivity of rice remains the main challenge considering that the 90% of the cultivated area of rice belong to small and marginal farmers. Among the various factors contributing to rice productivity, Nitrogen is one of the main factor responsible for contributing to increase in rice yield (47%) (Prasad *et al*., 2017). Hence provision of adequate supply of N throughout the growing period is essential for realizing potential yields (Sureka *et al*.,2016).Though the yield increase due to N fertilization in rice has been substantial (47%), the average agronomic efficiency of N is only 11.4 kg grain/kg N (Prasad, 2011) and nitrogen use efficiency is only (30-50%) due to losses of nitrogen under flooded condition in form of volatilization, denitrification and leaching (Johri and Yadav,2006 ; Prasad *et al*.,2014).

Achieving high nitrogen use efficiency in rice production has become a major challenge with increasing food demand, depletion of natural resources and environmental deterioration. The N content in Indian soils continue to be low ranging from 0.02% to 0.1% (Prasad,2007) a possible explanation is that enough organics are not introduced into the rice agro-systems and the applied N fertilizers are soluble and thus easily lost from the systems (Prakasa *et al*., 2016). Therefore, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields which helps in maintaining yield stability through enhancing efficiency of applied nutrients and providing favorable soil physical conditions (Gill and Walia, 2014). One of the major practices to achieve sustainability is to partially substitute the chemical N fertilizers with suitable organic manures which are available indigenously can improve soil health resulting in enhanced crop yield. The integration of organic manure with inorganic fertilizers is essential to achieve sustained production of rice and maintain the soil fertility for a longer period. (Gill and Walia, 2014). Integration of organic manure (Vermicompost/Poultry manure/ Fish manure) in the rice production system which helps to improve soil structure, microbial activity and contribute to improvement in rice production is receiving attention of research workers worldwide in recent

years(Mohana *et al*,2019). This will not only recycle organic wastes but also minimize the adverse environmental effects of mineral-fertilizer overuse.

Numerous studies of beneficial effect of long-term application of organic and inorganic fertilizer on rice yield has been reported by many research workers. (Han *et al.*, 2020, Qaswar *et al*.,2020). In these studies, organic amendments were added based on chemical fertilizer dosage such that total nutrient amounts in the field were increased. It is essential to determine the proper substitution ratios of organic sources of nitrogen with chemical fertilizers so that the nitrogen nutrient in the soil is optimum for crop growth. In view of the low nitrogen use efficiency in rice cultivation of coastal Karnataka and lack of information on the effectiveness of locally available organic sources of nitrogen such as poultry manure, vermicompost and fish manure in rice cultivation, an investigation entitled " Effect of integration of organic and inorganic sources of nitrogen on growth and yield of *kharif* rice (*Oryza sativa* L.)" was carried out for two years during *kharif* season of 2017 and 2018 with the following objectives.

1. To optimize the quantity of fertilizer Nitrogen when combined with organic manure.
2. To study the effect of integrated nitrogen management through organic and inorganic sources on growth and yield of transplanted rice.
3. To study the effect of integrated nitrogen management on nutrient uptake and. soil fertility
4. To select the best combination of organic and inorganic sources of nitrogen in terms of economics.

Chapter II

REVIEW OF LITERATURE

2.1 Effect of organic sources of nitrogen on performance of rice crop

2.1.1 Vermicompost

The results of the experiment conducted at ZARS, Mandya showed that application of recommended dose of fertilizer (100:50:50 kg N:P:K ha^{-1}) + 10 tons of FYM/ha recorded significantly higher growth parameters like plant height (63.1 cm), number of tillers (36.2 $hill^{-1}$), leaf area (1602 cm2 $hill^{-1}$) and dry matter production at harvest (151.1 g $hill^{-1}$). However, it was at par with 200 % recommended dose of nitrogen (RDN) equivalent through vermicompost/ha, 200 % RDN equivalent through FYM ha^{-1}, 150 % RDN equivalent through vermicompost ha^{-1} and 100 % RDN equivalent through poultry manure ha^{-1} (Siddaram *et al.,* 2010). In Maharashtra application of 50 % N through RDF + 50% N through vermicompost recorded higher growth attributes like plant height, No. of tillers per plant, panicle length, grains per panicle,1000-grain weight and yield parameters like grain yield (4.97 tons ha^{-1}) and straw yield (5.77 tons ha^{-1}) of rice variety GR 11 at Paigar District (Dekhane *et al*.,2014)

Ranjitha *et al.* (2013) conducted a field experiment on lowland rice at Rajendranagar (Andhra Pradesh) during *kharif* 2010 and noted that application of 50% recommended dose of nitrogen (inorganic) and remaining 50% RDN through vermicompost resulted in significantly higher growth parameters followed by 100% RDN (120 kg ha^{-1}) through inorganic and 75% RDN (inorganic) + 25% RDN through vermicompost.

2.1.2 Poultry manure

At TNAU Coimbatore, application of 50% of N as Urea + 50% of N as poultry manure recorded higher growth characters, yield attributes and grain yield in rice which was closely followed by application of 100% of N as Urea. Higher profit was obtained with 50% of N as Urea + 50% of N as poultry manure (Maragatham *et al*.,2010). The rice productivity increased with application of 90 kg P ha^{-1}along with combined application of animal manures, especially poultry manure at Dhaka, Bangladesh (Amanullah *et al* 2016).

Saidu and Abayomi (2015) from Nigeria reported that the rice grain yield was significantly higher in the treatment of combination of 1.0 tons $ha^{-1}$of poultry manure+20 kg Nitrogen/ha (2.51 tons ha^{-1}) compared to control (1.38 tons ha^{-1}).

Higher yield attributes and grain yield of rice was recorded with application of enriched poultry manure compost on equal N basis (2.3 tons ha^{-1}) which was however comparable with composted poultry manure (Sangeetha *et al* 2013).

2.1.3 Fish Manure

The results of an experiment conducted at West Bengal to study the effect of well decomposed fish meal on rice crop and its residual effect on succeeding crops of rapeseed and blackgram. Indicated that growth parameters, yield components and productivity of all the crops in sequence were maximum when fish meal was used as organic manure along with inorganic fertilizer at 75% of the recommended dose and its effects were as good as farm yard manure. The highest rice equivalent yield (9.62 tons ha^{-1}), net returns (Rs 43728 ha^{-1}) and net production value (1.86) were recorded when 75% recommended dose of NPK + 2 tons of well decomposed fishmeal ha-1 was applied to rice (Pal *et al* ,2010).

Fish wastes along with beneficial microbes (biofertilizers) can be converted into a complete fertilizer by composting which when applied to soil release abundant nutrients to crops and hence can be used as a cost effective eco-friendly product for organic agriculture productions (Rajeshwari *et al.,* 2018)

Among the present conventional methods for reutilization of fish waste as animal feeds and composting Suganya *et al*., (2015) suggested utilization of fish waste by composting which is a not only environmentally sound but also economical, odorless and a biological beneficial practice. Further suggested that fish waste could be reutilized as liquid fertilizer in various agricultural crops.

Yildrimi *et al.,* (2016) in an experiment consisting of fish manure, commercial fertilizer and the combination of fish manure and commercial fertilizer with four doses of nitrogen (0 kg/ha, 100 kg/ha, 150 kg/ha and 200 kg/ha) reported that treatments significantly affected the growth and chemical characteristics of lettuce. The best results with regard to plant growth and yield were obtained from 100 and 150 kg kg/ha nitrogen doses of the combination of fish manure and commercial fertilizer.

Chapter III.

METHODOLOGY

The experiment was conducted in the field of ICAR-Krishi Vigyan Kendra, Mangaluru of coastal Karnataka consecutively for two years (2017 and 2018) during kharif season to study the response of rice to integration of organic and inorganic source of nitrogen under midland situation. The results of the composite soil sample of the experimental site collected before experimentation indicated that soil was lateritic characterized by acidic pH (5.5) and EC value was 0.14 dSm^{-1}. The soil fertility status of the experimental field contained medium available nitrogen (380 kg ha^{-1}), high available phosphorus (97.4 kg ha^{-1}) and low available potassium (96.13 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with three replications. The treatments were marked as T-1 to T-11 comprising various combinations of organic and inorganic sources of nitrogen as detailed below.

T1- Control (only FYM 5 t/ha No nitrogen)

T2- Recommended 100 % Nitrogen (urea) As per Package of Practice 60:30:60 kg NPK/ha

T3- Recommended 75% Nitrogen (urea) +25% N through Vermicompost (VC)

T4-Recommended 50% Nitrogen (urea)+50 % N through Vermicompost (VC)

T5-Recommended 75% Nitrogen (urea) + 25% N through Poultry Manure (PM)

T6-Recommended 50 %Nitrogen (urea) + 50% N through Poultry Manure (PM)

T7-Recommended 75% Nitrogen (urea)+25% N through Fish manure (FM)

T8-Recommended 50% Nitrogen(urea) +50 % N through Fish manure (FM)

T9-100% N through Vermicompost (VC)

T10-100% N through Poultry Manure (PM)

T11-100% N through Fish Manure (FM).

Well decomposed Vermicompost (VC), Poultry Manure (PM) and Fish manure (FM) collected from well known sources were used in the experiment as organic source. These were collected and Random samples from these organic manure was collected and analyzed for their nutrient contents. The results are presented in Table 1

Table 1. Mean nutrient content of the organic manure resources used in the experiment (on dry weight basis)

Sl. No.	Organic Manure	Source	Nitrogen (%)N	Phosphorus (%) $P_2 0_5$	Potassium (%) $K_2 0$
1	Vermicompost	KVK Mangalore	1.18	1.12	0.90
2	Poultry Manure (Deep litter)	Vittal Gowda Poultry farmer Moorje Bantwal	1.95	1.61	1.85
3	Fish Manure	Bunder Mangalore	3.66	1.03	0.74

Based on equal nitrogen basis, required quantities of organic manures treatment wise were incorporated into the soil 20 days before rice transplanting. The popular medium duration rice variety MO-4 (Bhadra) was raised in nursery in June-2017 and June-2018. Twenty two day old seedlings were transplanted on during first week of July-2017 and second week of July 2018 at a spacing of 20 cm x 10 cm. The recommended dose of fertilizers (60:30:60 kg NPK ha^{-1}) were applied. Nitrogen was applied in three equal splits at transplanting, tillering and panicle initiation stage. Recommended crop management practices and plant protection measures were followed. The normal rainfall for the crop growth period from June to October 2017 was 3245 mm and rainfall was received 2792 mm. Bio metric observations for various growth parameters were recorded as per the objectives at 30, 60 and 90 days after transplanting and at harvest. Plant samples collected at harvest were analyzed for major nutrient uptake. Soil samples collected after harvest of the crop were analyzed for soil fertility parameters.

3.1 Soil sampling and analysis

Treatments wise composite soil samples were collected at a depth of 15 cm from each of replication using spade as per standard procedures before transplanting. At harvest, composite surface soil sample from a depth of 15 cm was collected to know residual fertility status from each treatment plot. The soil samples collected after harvest of crops were air-dried, powdered and allowed to pass through 2 mm sieve and were analyzed for physical and chemical properties using standard methods..

3.2 Chemical analysis

3.2.1 Soil reaction (pH, 1:2.5 ratio)

Soil pH was determined in 1:2.5 soil water suspension ratio. This suspension was stirred intermittently for half an hour and pH was measured by potentiometric method using glass electrode (Jackson, 1973).

3.2.2 Electrical conductivity (d Sm^{-1})

The electrical conductivity (EC) of soil was determined in 1:2.5 soil water suspension ratio using Conductivity Bridge and the results were expressed in dSm^{-1} (Jackson, 1973).

3.2.3 Available Nitrogen (kg ha^{-1})

Available nitrogen was determined by alkaline potassium permanganate method as described by Subbaih and Asija (1956). A known weight of soil was treated with an excess of 0.32 percent potassium permanganate with 2.5 percent NaOH solution. The liberated ammonia was trapped in boric acid mixed indicator solution and determined by titration against standard H_2SO_4. The available nitrogen content of the soil was calculated by following formula.

$$\text{Available N (Kg ha}^{-1}) = \frac{(\text{Sample TV - Blank TV}) \times N. \text{ of } H_2SO_4 \times 0.014 \times 2.24 \times 10^6}{\text{Weight of soil sample (g)}}$$

3.2.4 Available Phosphorus (kg ha^{-1})

Available phosphorus in soil was extracted by Bray's No. 1 method (0.03N NH_4F+0.025N HCl) and the content of phosphorus was determined by ascorbic acid blue color method at 660 nm (Jackson, 1973). The blue color developed by ascorbic acid its intensity was determined at 660 nm. The available phosphorus content of the soil was calculated by following formula.

$$\text{Available } P_2O_5 \text{ (Kg ha}^{-1}) = \frac{\text{ppm} \times \text{Volume of extractant} \times \text{Volume made} \times 2 \times 10^6 \times 2.29}{10^6 \times \text{Weight of soil sample} \times \text{Aliquot taken}}$$

3.2.5 Available potassium (kg ha^{-1})

Available potassium in soil was extracted with neutral normal ammonium acetate (pH 7.0).The quantity of potassium in the extract was determined by using flame photometry as described by Jackson (1973). The available potassium (kg ha^{-1}) was calculated using the following formula.

$$\text{Available } K_2O \text{ (kg ha}^{-1}) = \frac{\text{ppm} \times \text{Volume of extractant} \times \text{Volume made} \times 2.24 \times 10^6 \times 1.20}{10^6 \times \text{Weight of soil sample} \times \text{Aliquot taken}}$$

3.3 Collection of experimental data

Five hills were selected randomly from net plot and labelled for recording the observations in each treatment. The growth and yield parameters were recorded at 30,60,90 days after transplanting (DAT) and at harvest. The procedure followed for measuring various growth and yield parameters of transplanted paddy are given below.

3.3.1 Growth parameters of rice

3.3.1.1 Plant height (cm)

Plant height of five randomly selected hills was measured from the base of the plant to base of the fully emerged leaf at 30,60, 90 days after transplanting (DAT) and at harvest. While, after emergence of panicle, the plant height was measured from base of the plant to tip of the panicle and the mean of height is expressed in centimeter.

3.3.1.2 Number of tillers per hill

Number of tillers per hill from the randomly selected five selected hills in the net plot was recorded at 30,60,90 days after transplanting (DAT) and at harvest. The average of five hills was taken as number of tillers per hill.

3.3.1.3 Leaf Area Index (LAI)

The leaf area index was recorded at 30,60,90 days after transplanting (DAT) and at harvest. The length and breadth of third leaf from top in sample plants were measured at tillering and flowering stages. The leaf area index (LAI) was worked out as per the formula given by Yoshida *et al.*, (1976)

$$LAI = \frac{(L*B) \times \text{No. of leaves/ hill} * K}{\text{Spacing (cm)}}$$

where, L – Leaf length (cm)

B – Maximum width of the leaf (cm)

K - Constant factor of 0.65

3.3.1.4 Total Dry matter production per hill

The crop biomass was estimated by using plant samples which were drawn from each plot. Five hills were randomly collected outside the net plot area in each treatment by cutting close to the ground level at different crop stages (30,60,90 DAT and at harvest). These plants were first air dried in shade and then oven dried at 80$\pm$5°C for 48 hours to attain constant weight. Total dry matter (g $hill^{-1}$) was recorded and expressed as gram per plant.

3.4 Growth indices of rice.

3.4.1 Absolute growth rate

It indicates the increase in dry matter per unit time. It is expressed as gram of dry matter produced per day. Absolute growth rate is calculated by the following formula.

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, AGR=Absolutegrowthrateexpressedingramday^{-1}

W_1=Dry weight of plant at time t_1

W_2=Dry weight of plant at time t_2

3.4.2 Crop growth rate

It indicates the rate of crop growth per unit area per unit time. Crop growth rate is calculated by the formula as given by Watson (1952). It is expressed as g day^{-1}m^{-2}.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{P}$$

Where, CGR=Crop growth rate, expressed in gram day^{-1} m^{-2}

W_1=Dry weight of plant at time t_1

W_2 =Dry weight of plant at time t_2

P=Land area in m^2

3.5 Yield and yield components of rice.

3.5.1 Number of productive tillers per hill

Total number of productive tillers per hill from five selected hills was counted and the average is taken as number of productive tillers per hill.

3.5.2 Panicle length (cm)

Panicle length of five panicles selected at random from each plant sample of the replicated plots was recorded. just before harvesting by measuring the distance between base of the panicle and tip of the panicle and the mean was computed and expressed in centimeter.

3.5.3 Panicle weight (g)

Mean panicle weight was obtained by weighing randomly selected five panicles from each net plot and expressed as grams per panicle.

3.5.4 Grain weight (g)

Grain samples were drawn from net plot produce for recording 1000-grain weight. Only 1000-grains were sorted out and weight of these grains was recorded and expressed in gram.

3.5.5 Number of filled grains per panicle

Total numbers of filled grains from same five panicles selected for recording panicle length were counted and the mean was computed.

3.5.6 Number of unfilled grains per panicle

Total number of unfilled grains from same five panicles selected for panicle length were counted and the mean was computed.

3.5.7 Filled grains per panicle

Filled grains per panicle were determined by subtracting chaffy grains from total grain of each panicle which are used for total grain and chaffy grain counting. Average numbers of filled grains of the twenty panicles were taken into consideration.

3.5.8 Grain yield (kg ha^{-1})

The net plots were marked, harvested separately and total dried biomass yield from each net plot was recorded. After threshing, grains were separated, cleaned and weighed. Later the grain yield per net plot was computed on hectare basis and expressed in kg per ha.

3.5.9 Straw yield (kg ha^{-1})

Straw yield per net plot was worked out by subtracting respective total grain weight from the total biomass. Later the straw yields per net plot was computed on hectare basis and expressed in kg per ha.

3.6 Analysis of plant samples

3.6.1 Nitrogen (%)

Plant sample (0.5g) was digested with concentrated sulphuric acid and digestion mixture (K_2SO_4: $CuSO_4$, $5H_2O$: Selenium in 100: 20: 1 proportion) till a green residue was obtained. The digested material was distilled in an alkaline medium to liberate ammonia, the liberated ammonia was estimated by titrating against std. H_2SO_4 (Piper, 1966).

Digestion of plant sample

One gram of powdered plant sample was predigested by adding 6ml of concentrated nitric acid and keeping over- night. The sample was digested with 10 ml of di-acid mixture (HNO_3: Perchloric acid in 10: 4 ratio) until show white residue was obtained. The residue was cooled, and then diluted to a known volume using distilled water, filtered and used for further analysis.

3.6.2 Phosphorus (%)

Phosphorus was estimated using a suitable aliquot of the above digested extract by vandomolybdate phosphoric yellow color method (Piper, 1966).

3.6.3 Potassium (%)

Potassium content in the di-acid digested extract was determined using flame photometer as outlined by Piper (1966).

3.7 Uptake of plant nutrients

After the determination of nutrient concentration in the grain and straw samples, the values were multiplied by the corresponding dry matter yield to get uptake of nutrients.

3.8 Economics

The price of inputs that were prevailing at the time of their use was considered for working out the cost of cultivation. The details considered to work out the economics are given in Appendix – I

Gross returns the gross return was worked out by multiplying the economic produce by respective sale prices and expressed in $Rs.ha^{-1}$

Cost of cultivation = Cost of inputs, labor, power *etc.*

Net returns = The net returns was worked out by subtracting the total cost of .cultivation from the total gross returns in $Rs.ha^{-1}$

The benefit cost ratio was worked out by using the following formula.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

3.14. Statistical analysis and interpretation of data

. The data on all parameters was analyzed statistically following analysis of variance (ANOVA) according to methods described for randomized block design. The treatment means were compared using least significant difference (LSD) test. Fisher's method of analysis of variance was applied for analysis and interpretation of data as given by Gomez and Gomez (1984).The level of significance used in 'F' and 't' tests were P=0.05. Critical difference values were calculated wherever the 'F' test was significant.

Chapter IV

RESULTS AND DISCUSSION

The results of the experiment conducted for two years 2017 and 2018 are presented as hereunder. However, the pattern of treatments response was similar in both the years. Therefore, only pooled data of two years of the experimentation is presented in this chapter and discussed accordingly.

4.1 Effect of integrated nitrogen management on growth parameters

The integrated effect of organic and inorganic sources of nitrogen on growth parameters of rice [1] recorded at harvest is presented in Table-2.

Table-2. Growth parameters of rice at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)

Treatments (T)	Plant height (cm)	Number of tillers per hill	Leaf Area Index	Absolute growth rate g/hill/day)	Cumulative growth rate g/hill/day/m^{-2})	Total Dry matter production (gm per hill
T1 =Control	73.88	10.95	0.55	0.23	12.50	32.84
T2 =100%N(U)	85.29	16.28	0.91	0.43	21.64	43.87
T3=75%N(U)+25%N(VC)	91.22	17.95	0.96	0.32	15.92	53.75
T4=50%N(U)+50%N(VC)	94.29	20.37	1.38	0.48	24.04	67.73
T5=75%N(U)+25%N(PM)	87.50	18.85	0.98	0.28	14.14	48.90
T6=50%N(U)+50%N(PM)	91.53	19.80	1.20	0.34	17.11	61.52
T7=75%N(U)+25%N(FM)	87.42	19.17	0.75	0.34	16.86	55.39
T8=50%N(U)+50%N(FM)	90.30	18.72	0.77	0.28	13.86	58.70
T9=100%N(VC)	91.02	20.15	0.82	0.56	27.11	65.67
T10=100%N(PM)	90.39	19.84	0.87	0.67	31.86	65.67
T11=100%N(FM)	89.33	19.80	0.85	0.52	26.13	64.21
SEm±	1.95	0.88	0.015	0.22	7.85	2.16
CD (5%)	5.78	2.88	0.04	NS	NS	6.37

DAT= Days After Transplanting	VC= Vermicompost	Recommended Nitrogen (100 %)= 60 kg/ha
N= Nitrogen	PM= Poultry manure	Recommended Nitrogen (75 %)= 45 kg/ha
U= Urea	FM= Fish Manure	Recommended Nitrogen (50 %)= 30 kg/ha

The growth parameters i.e. plant height, number of tillers per hill, leaf area index and total dry matter production per hill at harvest differed significantly ($P \leq 0.05$) due to different substitution ratios of 25,50 and 100 percent of nitrogen supplied through organic sources of VC, PM and FM. The highest plant height (94.29 cm) , number of tillers per hill (20.37) Leaf area index (1.38)and total dry matter production per hill (67.73 g) was recorded in T4 where 50 per cent N was substituted by VC which was significantly higher compared to control (plant height-73.88 cm,

number of tillers per hill -10.95, Leaf Area Index-0.55 and total dry matter production- 32.84 g respectively). Significant increase in growth parameters might be due to greater availability and steady release of nutrients from organic sources (VC, PM and FM), which perhaps enabled the recovery of and improvement of growth parameters towards reproductive stage**.** Norman *et al.* (2005) reported that vermicompost has the potential in enhancing the plant growth due to the changes in physicochemical properties of soils, overall increase in microbial activity and plant growth regulators produced by microorganisms. However, the growth indices namely Absolute Growth Rate(AGR) and Cumulative Growth Rate (CGR) were not influenced by any treatments of integrated nitrogen management.

4.2 Effect of integrated nitrogen management on yield and yield parameters

The integrated effect of organic and inorganic sources of nitrogen on yield and yield parameters of rice [1] recorded at harvest is presented in Table-3.

The substitution of nitrogen at ratios of 25,50 and 100 per cent significantly influenced the yield and yield parameters of rice at harvest. The maximum number of productive tillers $hill^{-1}$ was recorded in treatment T4 where 50 per cent RDN was supplied through VC (17.49) followed by treatment T6 where 50 per cent RDN was supplied through PM (16.11) which were significantly ($P \leq 0.05$) higher compared to control (8.88). Variations in the number of productive tillers $hill^{-1}$ among the different treatments were mainly due to their variations in availability of nitrogen and other nutrients from the organic and inorganic sources supplied.. Adequacy of nitrogen probably favored the cellular activities during panicle formation and development that led to increase in number of bearing tillers. Miller (2007**)** reported that organic sources offer more balanced nutrition to the plants especially micronutrients which positively affect the number of tillers in plants

Among the treatments, the highest panicle length and panicle weight was recorded in T4 - 50 per cent RDN through VC (18.10 cm and 4.06 g respectively) which was significant($P \leq 0.05$) compared to T1-control (10.66 cm and 2.27 g respectively. The panicle length of the treatments receiving organic sources of nitrogen at different substitution ratios were on par with each other but were significantly ($P \leq 0.05$) higher than control. The total number of grains per panicle was significantly higher in T4 where 50 per cent RDN was supplied through VC (131.83) followed by T6-50 percent N by VC (128.05). The data on grain yield showed that significantly ($P \leq 0.05$) higher grain yield (5403 kg ha^{-1}) was recorded in the treatment T4- 50 per cent N through VC followed by T6-50 per cent N through PM

Table-3 : Yield and yield parameters at harvest as influenced by integration of organic and Inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)

Treatments (T)	Productive tillers per hill	Panicle length	Panicle weight(g)	Total Grains per panicle	Grain Yield (kg/ha)	Straw yield (kg/ha)
T1 =Control	8.88	10.66	2.27	98.50	3703	4501
T2 =100%N(U)	12.03	14.80	2.50	108.00	4617	5802
T3=75%N(U)+25%N(VC)	15.00	17.00	3.33	112.58	4799	5926
T4=50%N(U)+50%N(VC)	17.49	18.10	4.06	131.83	5403	6872
T5=75%N(U)+25%N(PM)	15.05	15. 67	3.66	125.09	4721	5912
T6=50%N(U)+50%N(PM)	16.11	16.94	3.64	128.05	5294	6585
T7=75%N(U)+25%N(FM)	14.05	15.24	3.49	116.50	4611	5736
T8=50%N(U)+50%N(FM)	15.77	15.99	3.54	120.82	4837	5988
T9=100%N(VC)	15.05	16.94	3.79	124.36	5179	6466
T10=100%N(PM)	13.74	15.94	3.67	123.55	4985	6218
T11=100%N(FM)	12.93	15.73	3.48	119.95	4926	6175
SEm+	0.88	1.04	0.10	1.55	202	228
CD (5%)	2.88	3.05	0.28	4.57	595	672

DAT= Days After Transplanting	VC= Vermicompost	Recommended Nitrogen (100 %)= 60 kg/ha
N= Nitrogen	PM= Poultry manure	Recommended Nitrogen (75 %)= 45 kg/ha
U= Urea	FM= Fish Manure	Recommended Nitrogen (50 %)= 30 kg/ha

(5294 kg ha^{-1}) and T9 -100 percent N through VC (5179 kg ha^{-1}) compared to T1-control (3703 kg ha^{-1}) but were on par with each other.The straw yield was significantly ($P<0.05$) higher in the treatment T4- 50 per cent N through VC (6872 kg ha^{-1}) compared to T1-control (4501 kg ha^{-1}). This was followed by treatment receiving T6-50 per cent N through PM which recorded straw yield of 6585 kg ha^{-1} and treatment T9 – 100 percent VC (6466 kg ha-^{1}). Higher yields in the treatment receiving VC might be due to increased availability of nutrients, presence of beneficial micro flora and plant growth regulators like gibberellins, auxins etc. This might have provided balanced availability of nutrients to assimilate sufficient photosynthates for increased dry matter production by positive conversion of source to sink reflecting in form of more productive tillers, higher panicle length leading to higher grain and straw yield. Roy and Singh (2006) stated that increased growth and yield components of crops due to application of vermicompost was mainly because of microbial stimulation effect and N supplied through gradual mineralization in a steady manner throughout the crop growth period. Dekhane *et al* (2014) from Maharashtra reported beneficial effect of vermicompost on growth and yield attributes of rice variety GR-11 when

Plate.1 Layout of the experiment

Plate 2. General view of the experiment first year -2017

Legend

1. Control (No Nitrogen)

2. Recommended 100 % Nitrogen (urea)

3. Recommended 75% Nitrogen (urea) +25% N through Vermicompost (VC)

4. Recommended 50% Nitrogen (urea)+50 % N through Vermicompost (VC)

5. Recommended 75% Nitrogen (urea) + 25% N through Poultry Manure (PM)

6. Recommended 50 %Nitrogen (urea) + 50% N through Poultry Manure (PM)

7. Recommended 75% Nitrogen (urea)+25% N through Fish manure (FM)

8. Recommended 50% Nitrogen(urea) +50 % N through Fish manure (FM)

9. 100% N through Vermicompost (VC)

10.100% N through Poultry Manure (PM)

11.100% N through Fish Manure (FM).

Recommended Dose of Fertilizers 60:30:60 Kg N, P2O5, K20 per ha

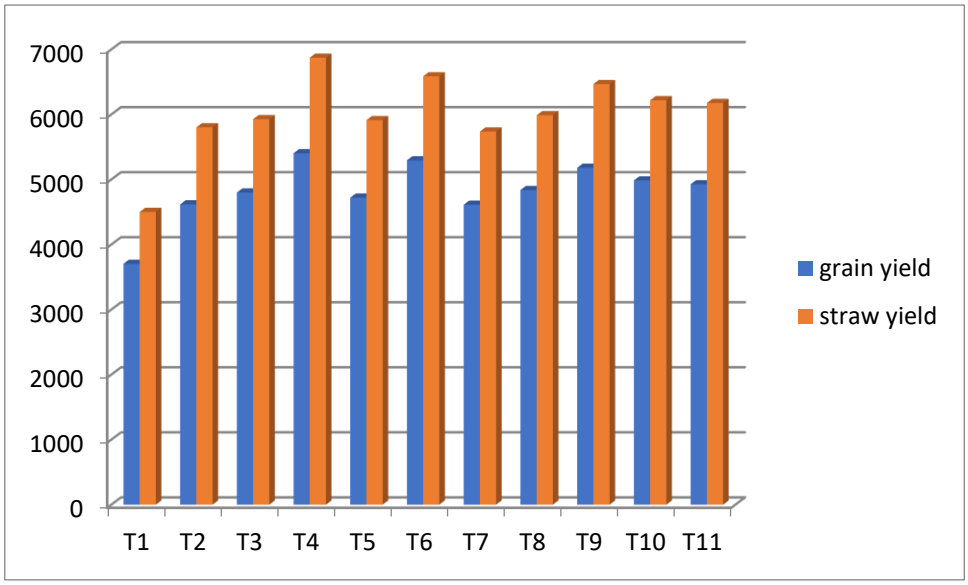

Figure 1. Grain yield and Straw yield at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during kharif season (Pooled data of two years)

50 percent of recommended nitrogen was substituted by vermicompost while Kyi moe et al (2019) reported from china that integrating nitrogen through poultry manure at 50 percent of the recommended dose enhanced growth parameters and yields of rice. Paramesh *et al.,* (2014) also reported that 50 per cent RDN through chemical fertilizers + 50 per cent RDN through vermicompost recorded significantly higher plant height, leaf area, number of tillers hill^{-1}, total dry matter accumulation hill^{-1}, grain yield and straw yield in rice.

4.3 Effect of integrated nitrogen management on soil fertility status

The integrated effect of organic and inorganic sources of nitrogen on soil pH, Electrical Conductivity (EC), Available Nitrogen(Kg ha^{-1}), Available Phosphorus (Kg ha^{-1}) and Available Potassium(Kg ha^{-1}) at harvest during kharif season are presented in Table-4

Table-4 : Soil fertility status at harvest as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years).

Treatments (T)	pH	EC dSm	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
T1 =Control	5.11	0.046	297.53	46.42	95.31
T2 =100%N(U)	5.12	0.052	319.71	67.78	128.25
T3=75%N(U)+25%N(VC)	5.13	0.045	380.20	69.38	136.05
T4=50%N(U)+50%N(VC)	5.20	0.048	389.18	69.22	146.15
T5=75%N(U)+25%N(PM)	5.19	0.050	361.62	71.22	135.40
T6=50%N(U)+50%N(PM)	5.18	0.046	367.66	79.47	142.80
T7=75%N(U)+25%N(FM)	5.16	0.050	353.15	63.25	130.35
T8=50%N(U)+50%N(FM)	5.26	0.049	355.88	69.00	134.60
T9=100%N(VC)	5.06	0.051	356.30	56.63	123.60
T10=100%N(PM)	5.32	0.050	348.60	61.22	138.15
T11=100%N(FM)	5.28	0.049	340.65	55.26	131.20
SEm+	0.14	0.020	8.80	4.08	2.22
CD (5%)	NS	NS	25.86	10.91	6.60

DAT= Days After Transplanting	VC= Vermicompost	Recommended Nitrogen (100 %)= 60 kg/ha
N= Nitrogen	PM= Poultry manure	Recommended Nitrogen (75 %)= 45 kg/ha
U= Urea	FM= Fish Manure	Recommended Nitrogen (50 %)= 30 kg/ha

4.3.1 Soil pH and EC

The pH and electrical conductivity of the post-harvest soil samples varied within a narrow range among different treatments and the differences were statistically ($P \leq 0.05$) non-significant.

The soil pH values was not significantly ($P<0.05$) influenced by the integrated nitrogen application through organic and inorganic sources in rice. However, the pH of the treatments varied from 5.06 to 5.32 indicated acidity of the soils. The highest pH value was recorded in treatment T10-100 percent PM (5.32) followed by treatment T6- 50 percent PM (5.26) and T8- 50 per cent FM (5.26) The Electricity Conductivity (EC) was not significantly($P \leq 0.05$) influenced by integrated application of organic and inorganic sources of nitrogen. However, the EC values ranged from 0.046 dSm^{-1} in control to 0.0.052 dSm^{-1} in T-2 (recommended nitrogen). The acidity of the soil and low EC could be attributed to high degree of leaching of bases and soluble salts due to heavy rainfall received during the crop growth period. Sharma *et al* (2013) reported decline in soil *p*H due to the formation of organic acids by decomposition of organic manure and crop residues.

4.3.2 Available Soil Nitrogen (N)

The soil available nitrogen , phosphorus and potassium was significantly ($P \leq 0.05$) influenced by different treatment combinations of organic and inorganic sources of nitrogen in rice.. The treatment T4 50 per cent VC)recorded significantly ($P<0.05$) higher available nitrogen (389.18 kg ha^{-1}) and higher available potassium VC (143.7 kg ha^{-1}) compared to control (294.05 kg ha^{-1}) but was on par with the treatment T3 (POP +25 per cent VC) which recorded 374.80 kg ha^{-1} of available nitrogen. All the treatments comprising combinations of organic and inorganic sources of nitrogen recorded significantly ($P \leq 0.05$) higher available soil nitrogen compared to T1-control and T2-POP. The lowest soil available nitrogen was recorded in control (294.05 kg/ha) followed by treatment T2 –POP (313.41 kg ha^{-1}). Vermicompost, poultry manure and fish manure might have attributed to the mineralization of N in soil and promoting of microbial activity. This may have resulted in the conversion of the organically bound nitrogen to inorganic form which might have increased the transformation of nutrients to available form and improving N availability in soil. Similar increase in available N in soil due to addition of organics was observed in rice (Singh *et al*., 2006).

4.3.3 Available Phosphorus(P_2O_5)

The available phosphorus (kg ha^{-1}) in soil after harvest of rice was significantly ($P \leq 0.05$) influenced by different treatment combinations of organic and inorganic sources of nitrogen. Treatment T6 (POP+ 50 per cent PM) recorded significantly higher available phosphorus (78.83 kg ha^{-1}) compared to T1- control (43.93 kg ha^{-1}) and T2- POP (65.25 kg ha^{-1}) but was on par with treatment T5-POP+per cent PM (70.23 kg ha^{-1}). The treatments T3- POP+25 per cent VC (66.26 kg ha^{-1}), T4- POP+50 per cent VC (68.23 kg ha^{-1}), T7- POP+25 per cent FM (62.30 kg ha^{-1}) and T8- POP+50 per cent FM (68.50 kg ha^{-1}) were on par with each other. However the available phosphorus content recorded with absolute control was significantly($P \leq 0.05$) lower than rest of the treatments. Higher availability of soil Phosphorus in T6 might be due to coating of sesquioxides by organic materials that reduced P-fixation in soil and promoted release of carbon dioxide and organic acids solubilizing the native soil Phosphorus**.** Laxminarayana (2006) also found similar improvement in soil available P status due to integrated nutrient management in rice

4.3.4 Available Potassium(K_2O)

The available Potassium was significantly ($P \leq 0.05$) higher in the treatment T4-POP+50 per cent VC (143.7 kg ha^{-1}) compared to treatment T1-control (92.31 kg ha^{-1}). This was followed by treatment T6 POP+50 per cent PM (141.8 kg ha^{-1}). The treatment T2- POP (125.1 kg per ha^{-1}) was on par with T7-POP +25 per cent FM (128.4 kg per ha^{-1}) but was significantly ($P \leq 0.05$) higher than control. The beneficial effect of VC on available potassium might be due to the reduction of K fixation, solubilizing action of certain organic acids produced during decomposition and its greater capacity to hold K in the available form, thereby increasing absorption of K. Prasad *et al* (2010) also reported beneficial effect of vermicompost on residual soil fertility because of slow release of nutrients and reduction of nutrient losses.

4.4 . Economics

The economics of the integrated nitrogen management on economics of rice are presented in Table.5

Table-5 : Economics of rice production as influenced by integration of organic and inorganic sources of nitrogen in rice during *kharif* season (Pooled data of two years)

Treatments (T)	Cost of cultivation Rs/ha	Gross returns Rs/ha	Net returns Rs/ha	Benefit cost ratio
T1 =Control	42875	86937	44062	2.03
T2 =100%N(U)	52305	109250	56945	2.09
T3=75%N(U)+25%N(VC)	55432	113043	57011	2.04
T4=50%N(U)+50%N(VC)	58553	128216	69663	2.19
T5=75%N(U)+25%N(PM)	55945	111604	55659	1.99
T6=50%N(U)+50%N(PM)	59579	124942	65363	2.10
T7=75%N(U)+25%N(FM)	55380	109471	54091	1.98
T8=50%N(U)+50%N(FM)	58449	114007	55558	1.95
T9=100%N(VC)	65701	122239	57438	1.86
T10=100%N(PM)	66853	117724	50871	1.76
T11=100%N(FM)	64593	116478	51885	1.80

DAT=Days After Transplanting	VC= Vermicompost	Recommended Nitrogen (100 %)= 60 kg/ha
N= Nitrogen	PM= Poultry manure	Recommended Nitrogen (75 %)= 45 kg/ha
U= Urea	FM= Fish Manure	Recommended Nitrogen (50 %)= 30 kg/ha

Higher Gross Returns (Rs. 128216/- ha^{-1}) and Net Returns (Rs. 69663/- ha^{-1}) were realized with substitution ratio of 50 per cent RDN through vermicompost followed by substitution of 50 per cent RDN through poultry manure (Rs. 124942/- ha^{-1} Gross Returns and Net Returns Rs.65363/- ha^{-1}) compared to 100 percent N through (Rs. 109250/- ha^{-1}.and net returns of Rs.56945/- ha^{-1}). While, lowest gross returns and net returns were obtained with control (Rs.86937/- ha^{-1} and Rs.44062/- ha^{-1} respectively) where no manures and fertilizers were applied. Similar findings of substitution of nitrogen by organic sources was also reported by Reddy *et al* (2019).From the economic analysis, it is imperative that substitution of 50% of RDN with vermicompost followed by substitution of 50% of RDN with poultry manure would be advantageous in terms of cost effectiveness and higher returns per rupee investment.

4.5 .Salient findings of the study.

- ✓ The substitution ratios of organic manures namely vermicompost, poultry manure and fish manure had beneficial effect on growth and yield parameters of rice. Vermicompost substituted at 50 percent of nitrogen resulted in better growth performance as indicated by the growth parameters of plant height, number of tillers per hill and total dry matter production.
- ✓ The rice yield was significantly higher in treatment where 50 percent of nitrogen was substituted by vermicompost followed by 50 percent substitution of nitrogen by vermicompost compared to control and application of recommended dose of nitrogen (100 percent through urea)
- ✓ The study indicated that soil fertility status was improved with highest available nitrogen and potassium being recorded in treatment where 50 percent nitrogen was substituted by vermicompost whereas substitution of 50 percent of nitrogen through poultry manure recorded highest available phosphorus compared to control.
- ✓ From the economic analysis the study indicated that substitution of chemical fertilizer urea as source of nitrogen with organic sources of vermicompost and poultry manure was advantageous for rice crop production.

4.6 Future lines of work

- ➢ Long term fertility studies of using organic sources of nitrogen like vermicompost poultry manure and fish manure in rice -legume cropping system in coastal Karnataka.

Chapter-V

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LIST OF PUBLICATIONS

***A.Research Papers* (3)**

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A2. Harish Shenoy and Siddaraju. M. N (2020) Effect of integrated nitrogen management through organic and inorganic sources on yield of rice (*Oryza sativa* L) and status of soil fertility at harvest. *Journal of Applied and Natural Science.*12(4) 721-727 (Print ISSN: 0974-9411) (online ISSN: 2231-5209 online). https://doi.org/10.31018/jans.v12i4.2433

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***B. Abstracts* (4)**

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